Global Journal of Computer Science and Technology: C
Software & Data Engineering
Volume 17 Issue 1 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Kanban based Scheduling in A Multistage and Multiproduct System

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GJCST-C Classification: *J.5, H.5.5, D.2.5*

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Abstract- In the highly competitive manufacturing environment, many companies around the world are searching for ways to improve manufacturing performance. This is in response to changes in the manufacturing environment reflected by shortened product life cycles, diverse customer needs and the rapid progress of manufacturing technology. A JIT tool otherwise referred to as kanban based scheduling is then considered as a suitable management concept for Juhel Pharmaceutical Nigeria Ltd to address the challenges by minimising all the components, particularly on the shop floor. The JIT system is not just related to Kanban implementation but it comprises an all-inclusive approach for improving batch size reduction, setup time reduction, quality, production planning, and human resources management. Mechanisms and operating procedures are required to provide detailed step-by-step instructions for the implementation of a pull system. Basically, the Drug Process Plant operations are mainly characterised by single flow line production processes, periodical and multi-items orders. Based on the evaluation of the implementation of the new system, there are some factors that must be considered for further improvement including inventory reduction, improving visibility, batch size reduction and matching with other systems.

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I. Introduction

Manufacturing firms are currently encountering problems because of changing environment, varying weather conditions, product design changes and rapidly changing customer demand. Thus, the Manufacturing Resource Planning (MRP) system and the Mass Production System (MPS) cannot respond quickly enough to the product design changes. This results in, amongst other things, high levels of obsolete stocks.

Also, manufacturing environment could be too turbulent to allow accurate forecasting. This results in excessive obsolescence. This can only be improved by reducing the lead time below what can be achieved by Manufacturing Resource Planning (MRP). However, the need to be more responsive to rapidly changing customer demand as a result of market competition remains a constant dominant challenge. In the highly competitive manufacturing environment, many companies around the world are searching for ways to improve manufacturing performance. This is in response to changes in the manufacturing environment reflected by shortened product life cycles, diverse customer needs and the rapid progress of manufacturing technology (Uwakwe, 2015).

Amongst the available technology and systems is Just-In-Time (JIT), a Japanese manufacturing concept that puts emphasis on *waste* elimination. This is a suitable means for a company that wants to perform in a competitive market. Some potential benefits that can be achieved by applying JIT concepts include: significant reduction of setup time, reduced cost of quality (such as scrap/rework reduction), increased inventory turn-over, increased manufacturing flexibility and shorter lead time (Melitus, Kevin, & Collins, 2016). Companies operating in highly competitive environments are the most appropriate for implementing JIT concepts.

There are four motives for using JIT in industries (Vincent and Abdul-Karim, 2009). First, some industries are characterised by a short product life cycle, for that reason, lead time and inventory reduction must become main concerns. Secondly, a large percentage of the cost of goods sold is material cost so decreased inventory and scrap is very essential. Thirdly, the collective effects of short life cycle and high material costs lead to a high level of material obsolescence, thereby, decrease in lead time and inventory again becomes main concerns. Finally, rapid technological advancement causes shorter life cycle so the company must be able to reduce time required to meet up with customer needs.

In this paper, a serial multi-stage manufacturing system controlled by Kanbans is considered which acquires raw materials from outside suppliers and route them through multiple work-stages to produce a varying quantity of finished products to customers at a fixed-interval of time (Figure1). The raw materials are also replenished instantaneously to the manufacturing system to meet the JIT operation and time-varying finished product demand model, and the production capability of the system is flexible.

An ideal JIT manufacturing system produces only the right items in right quantities at right time. Traditional manufacturing facilities carry large inventories of finished goods to satisfy the demands of customers that adopt a JIT delivery system. In the newly proposed JIT system, lot sizes are compact as much as possible and deliveries of products are scheduled repeatedly. The express impact of the JIT system is decrease of inventory holding cost.

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As a result, the manufacturer should get exact knowledge of demands of finished products and sustain an optimum production schedule to match the supply chain manufacturing system. If production is synchronized with the customers' lumpy demands and the ordering of raw material with production schedules is properly coordinated, all raw materials, WIP and finished goods inventories could be sustained at an economic level in a manufacturing firm to reduce the integrated inventory cost incurred due to raw materials, WIP, and finished products.

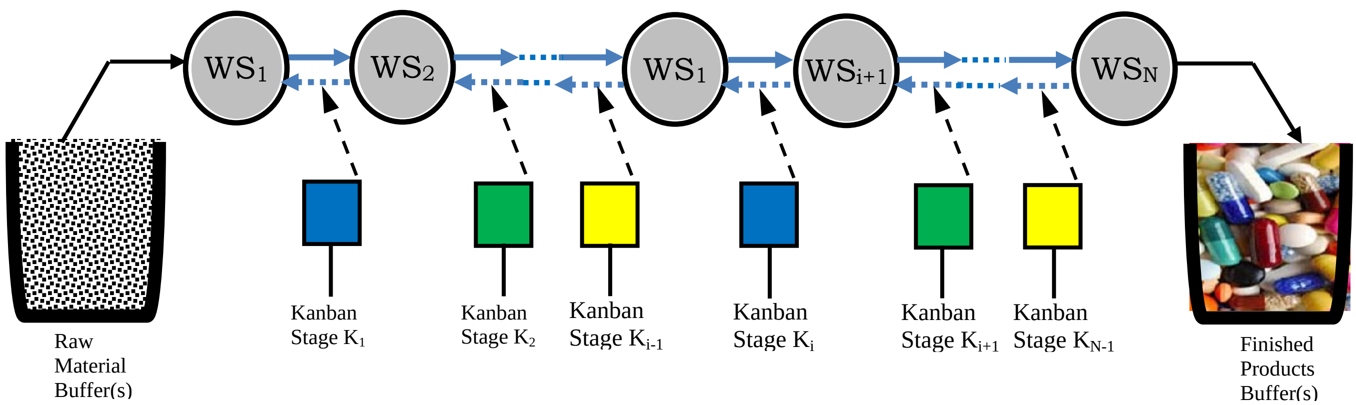

Figure 1: A serial multi-stage drug manufacturing system with Kanban operations

II. Materials and Method

One of several indicators that pharmaceutical companies are able to survive within the global marketplace is their ability to improve return on assets (ROA). ROA will improve if either turnover or return on sales (ROS) increases. Turn over that is obtained by dividing sales into assets can be increased if assets decrease. Since in a pharmaceutical company, inventory is a major part of assets, inventory reduction will improve turnover significantly. Similarly, ROS will increase if operating profit that is obtained by subtracting sales against total costs and expense increases. Since in such companies inventory is a major part of the total cost, inventory reduction will significantly improve ROS. Therefore, inventory reduction, is a key factor for improving ROA and eventually to survive global competition (Mathew, Bali & Edmund, 2014).

These considerations require the companies to find better ways for reducing various type of inventory such as raw materials, WIP and finished goods. JIT is then considered as a suitable management concept for Juhel Pharmaceutical Nigeria Ltd to address the challenges by minimising all the components, particularly on the shop floor.

a) An Overview about the Drug Process Plant

Basically, the Drug Process Plant operations are mainly characterised by single flow line production processes, periodical and multi-items orders. There are around 97 periodical items produced by the Drug Process Plant with Mechanisms and operating procedures are necessary to provide detailed step-by-step instructions for the implementation of a pull system. These management tools must be developed clearly so all people working with this the order quantity ranging from one pallet to 700 pallets. With such characteristics, it is not surprising that MRP was then introduced to control the plant.

b) Products

Basically, items produced by the Drug Process Plant can be classified into three types as shown in figure 2: Product A otherwise referred to as tablets (55% of order volume), Product B otherwise known as capsules (35% of order volume) and Product C otherwise referred to as pills (10% of order volume).

c) Layout

Because of the type of manufacturing processes, the Drug Process Plant employs product flow layout as shown in the Figure 3. The benefit of this layout is that the process paths are clear so everyone understands what the next process is. Unfortunately, because of space constraint and the size of particular machines, most process paths are not straight lines so the processes necessitate extra time for transport as a result of extra distances. Moreover, these problems also lead to other problems such as unfixed locations of buffers so WIP and inventory are not observable.

d) Designing Mechanisms or Operating Procedures for Running the System

system understand how to accomplish the task. Diagrammatically, the mechanisms of the pull system at the Drug Process Plant are based on the design of the system as shown in Figure 4.

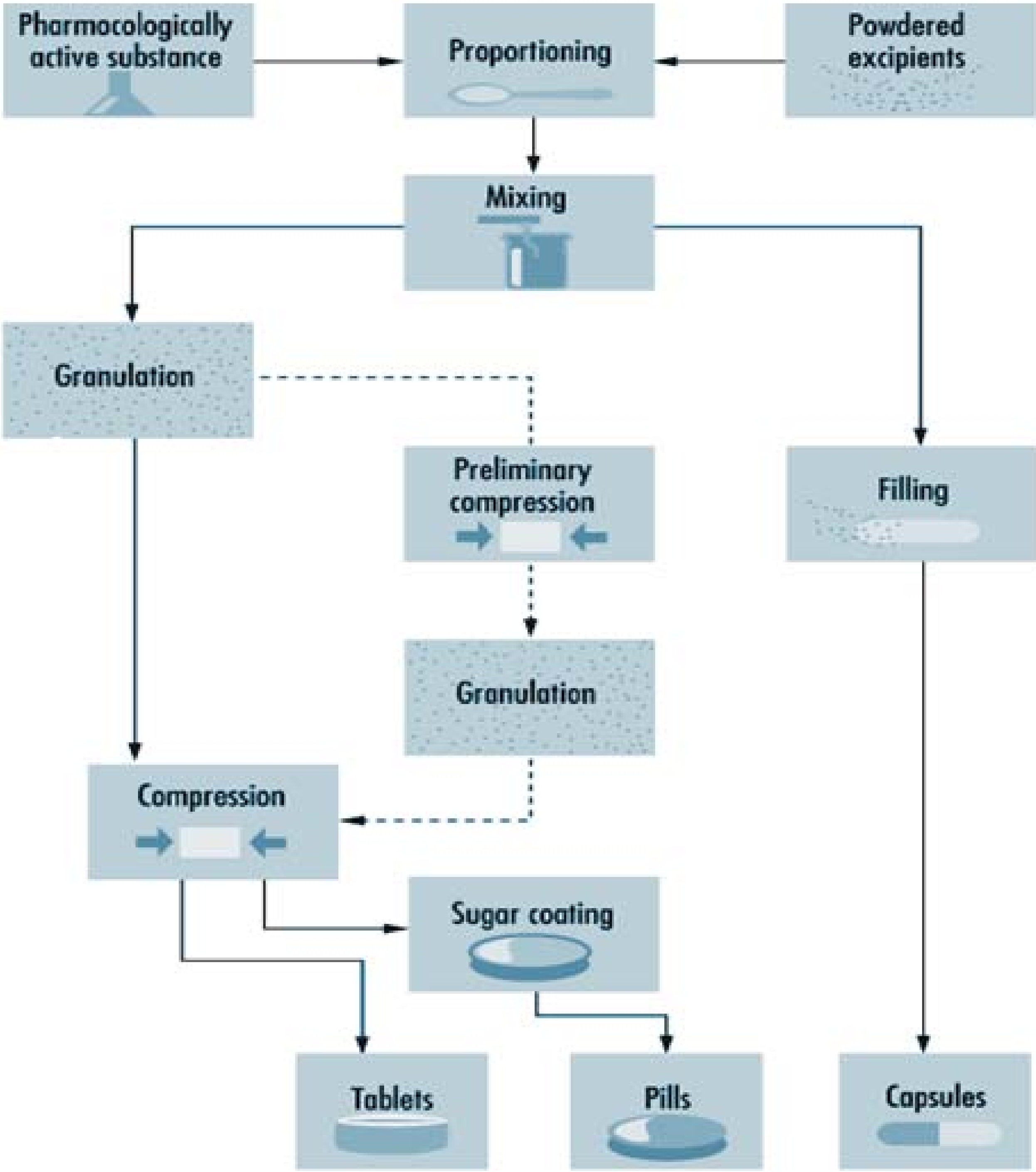

Figure 2: Items Produced by the Drug Process Plant

The mechanisms of the novel pull system can be illustrated in the following procedures. Customers pull in to pick up full containers of sub-pallets from the Operators in the blister packing/strip sealing section must check the board whether there are cards or not. If there are cards, they take the cards and start production by taking raw materials from buffer 2 and putting them into the unfilled containers. The quantity of raw materials taken is equal to the total Kanban quantity detached from the board. If buffer storage area (end buffer). When taking the containers, they must put green Kanbans from the full containers on board 2.

2 reaches the trigger point, they place the yellow Kanban from buffer 2 onto board 1. Operators in the mixing/blending section must check this board. If there is a yellow Kanban, they must take this card and start the production. In this block, the production quantity is 360 units as printed on the yellow Kanban. The numbers in the flow chart refer to activities as shown in Figure 4.

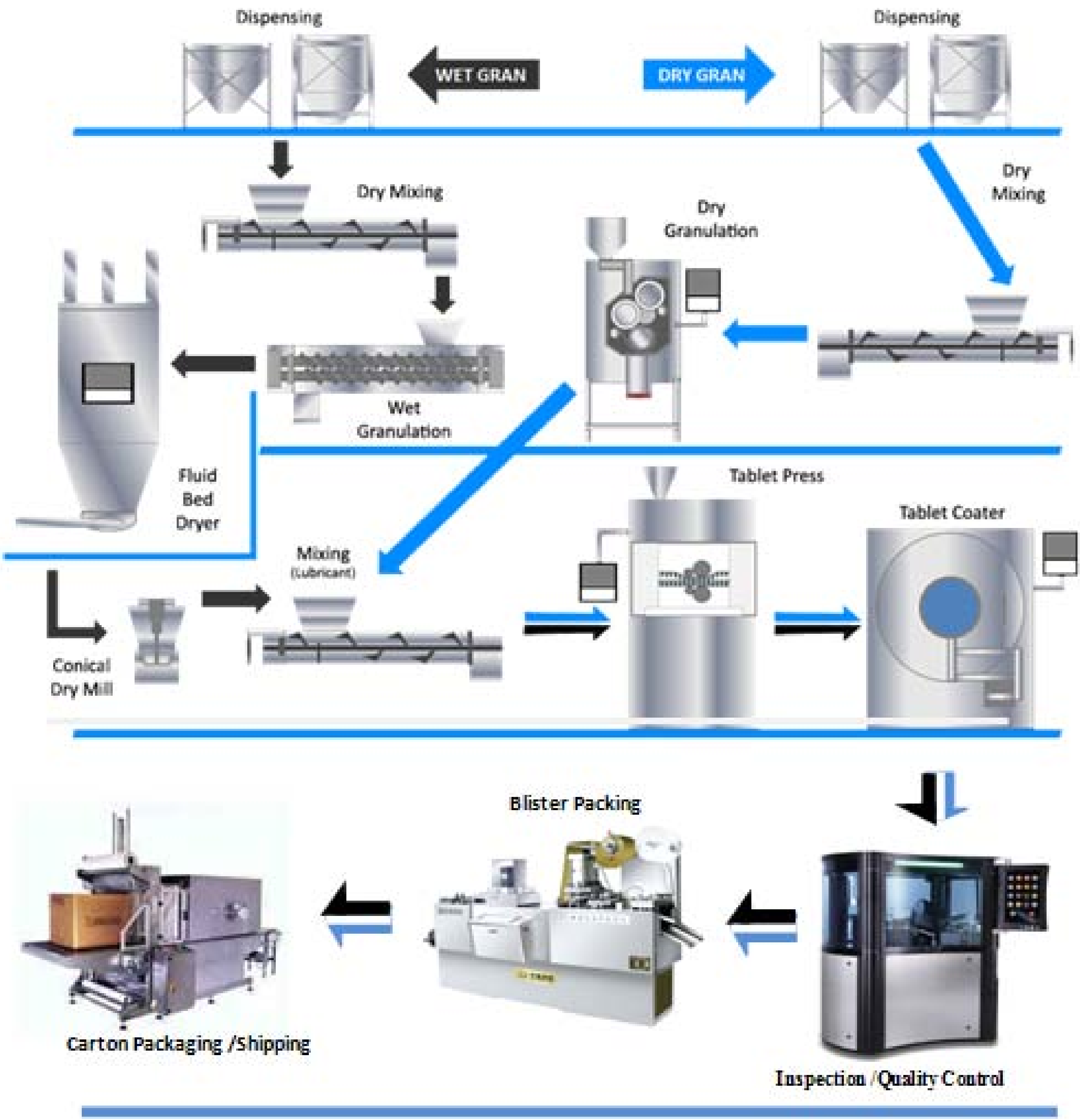

Figure 3: General Layout of the Drug Process Plant

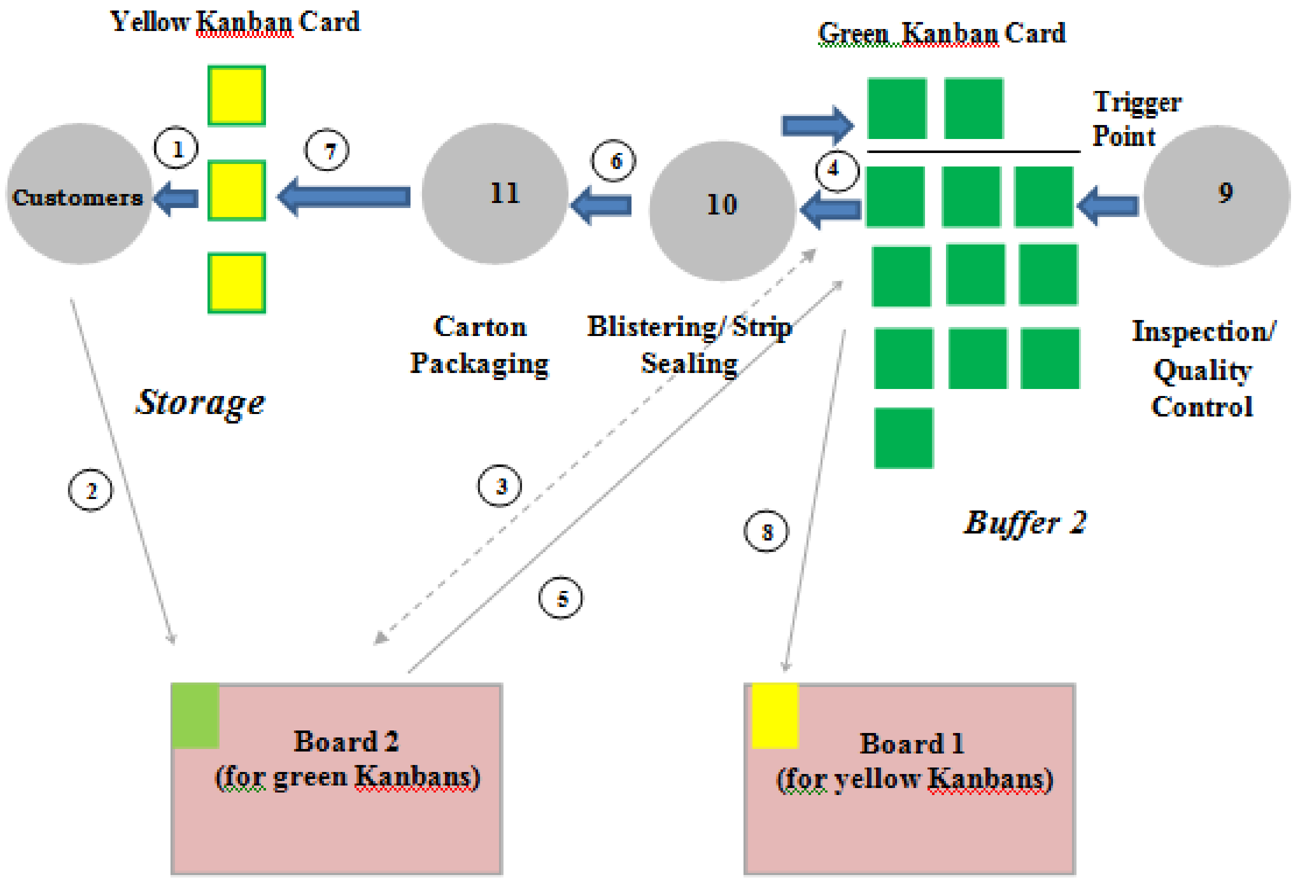

Figure 4: Mechanism of JIT System

III. Results and Discussion

a) Raw Data and Descriptive Statistics

Because the data were generated through an ARENA simulation model and manually entered into an Excel spreadsheet for sorting and calculations uploading into SPSS, the possibility of researcher error in transferring the data exists. The product costs were first determined in the simulation model by using different manufacturing system alternatives: Mass Production System (MPS), Material Resource Planning System (MRP), and Just in Time Manufacturing System (JIT). The product cost data were then input into the Integer Linear Programming (ILP) model to determine the optimal product mix, which was then input into the simulation model for use in the product mix decision. Average performance data were collected for 60 replications of 30 days each for 27 experimental condition groups, representing three different Manufacturing Systems (MAS) (Mass Production System (MPS), Material Resource Planning System (MRP), and Just in Time Manufacturing System (JIT)), three levels of manufacturing overhead (low, medium, high), and three levels of product mix complexity (low, medium, high) for a total of 1620 data points. Table 1 below shows the number of observations by experimental factor.

b) Practical Implications

Because the primary focus of this study is to examine the impact of kanban based scheduling on manufacturing performance in the context of a time-based competitive environment, it is necessary to take a more detailed look at this impact on each individual performance measure. The three performance measures were chosen because they represent both internal and external and financial and non-financial measures of performance. Table 1 below presents a summary of the results in performance measures by manufacturing system alternative.

Demand fulfillment rate measures an external (market) non-financial representation of manufacturing performance. It corresponds to the percentage of demand that is ultimately fulfilled by the production system. The maximum performance in terms of this measure was Material Resource Planning System (MRP) (MAS_2) with 86.6% of demand fulfillment rate and Just in Time Manufacturing System (JIT) (MAS_3) with 85.4% of demand fulfillment rate. The most abysmal performance was Mass Production System (MPS) (MAS_1) with 69.8% of demand fulfillment rate. Even though the difference between MRP and JIT in terms of demand fulfillment rate was statistically significant, from a practical perspective, this difference may not corroborate the high cost of implementing an MRP system.

Table 1: Multiple Comparisons by MAS

Scheffe

Dependent Variable	(I) MAS	(J) MAS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
DFR_2	1	2	-.16799907*	.000245697	.000	-.16860104	-.16739710
		3	-.15545861*	.000245697	.000	-.15606058	-.15485664
	2	1	.16799907*	.000245697	.000	.16739710	.16860104
		3	.01254046*	.000245697	.000	.01193849	.01314244
	3	1	.15545861*	.000245697	.000	.15485664	.15606058
		2	-.01254046*	.000245697	.000	-.01314244	-.01193849
CT_2	1	2	-29.211410*	1.91319765	.000	-33.89883996	-24.52397938
		3	53.468745*	1.91319765	.000	48.78131487	58.15617545
	2	1	29.211410*	1.91319765	.000	24.52397938	33.89883996
		3	82.680155*	1.91319765	.000	77.99272454	87.36758512
	3	1	-53.468745*	1.91319765	.000	-58.15617545	-48.78131487
		2	-82.680155*	1.91319765	.000	-87.36758512	-77.99272454
NOI_2	1	2	-6.3592155*	.124743740	.000	-6.66484388	-6.05358703
		3	-.10501750	.124743740	.702	-.41064593	.20061092
	2	1	6.35921545*	.124743740	.000	6.05358703	6.66484388
		3	6.25419795*	.124743740	.000	5.94856952	6.55982637
	3	1	.10501750	.124743740	.702	-.20061092	.41064593
		2	-6.2541979*	.124743740	.000	-6.55982637	-5.94856952

Based on observed means.
The mean difference is significant *. at the .05 level.

IV. Conclusion

Based on this evaluation, the differences between using the previous system and the new system are recapitulated in the Table 2. The JIT system is not just associated to Kanban implementation but it involves an all-inclusive approach for enhancing the performance of a system that covers batch size reduction, setup time reduction, quality improvement, production planning, and human resources management. Therefore, there will be more significant results if the enhancement also covers those areas using an integrated approach.

Table 2: The Results of the Implementation

OUTCOME	BEFORE JIT	AFTER JIT	IMPROVEMENT
Lead time	10 days	2 day	5 times
Inventory	1080 units (2 x360 +360)	540 units (90 + 360)	50%
Visual Control	None	Self-Driven	Better
Employee Motivation	Normal	Higher	Better

Based on the assessment of the implementation of the new system, there are some factors that must be put into consideration for further improvement including inventory reduction, improving visibility, batch size reduction and matching with other systems.

V. Acknowledgement

The authors acknowledge that the manuscript submitted is their own original work. All authors participated in the work in a substantive way. The submitted manuscript is reviewed and approved by all authors. The authors thank Juhel Nigeria Ltd for providing data for the problem. This study was conducted at Juhel Nigeria Ltd. The authors are grateful to all who provided various forms of assistance during this study.

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